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Project NY 300 006-3  
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interim technical note

INVESTIGATION OF UNPRESSURIZED SHELTER REQUIREMENTS  
AND EQUIPMENT

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## SUMMARY

Project NY 300 006-3 outlines a requirement for developing methods and materials to provide an unpressurized shelter for passive defense against CBR agents. A method for entrance, exit and air supply is necessary and the shelter walls must prevent penetration of gas and aerosols.

Development of satisfactory entrance and exit methods present the most difficult problems. It is possible to use or convert certain types of existing walls to impermeable walls for gas and aerosol protection. An air supply may then be obtained with diffusion materials or manually operated collective protectors. Development and testing of many items is required, but it appears that useful ventilated unpressurized shelters can be created.

## INTRODUCTION

Pressurized shelters offer complete protection against CBR agents, but are expensive. Project NY 300 006-3 was assigned to NAVCERELAB, Port Hueneme, California by the Bureau of Yards and Docks for the development of a shelter kit to convert existing structures to unpressurized shelters that provide economical emergency atmospheric protection. Two types of unpressurized shelters are considered in this discussion, (1) an unventilated sealed shelter with oxygen supplied by chemicals and (2) a ventilated sealed shelter using a manually operated collective protector or diffusion barrier material. The major functional requirements of unpressurized shelter facilities are:

- (a) Provide an enclosure which is CBR agent-proof
- (b) Decontaminate personnel entering
- (c) Allow personnel to leave without contaminating interior
- (d) Supply purified air to occupants
- (e) Provide personal necessities such as food, water, toilet facilities, and emergency clothing

Means of providing these functions are discussed in the following paragraphs.

## SHELTER FACILITIES

### General Requirements

The shelter will preferably be an existing building or portion of a building modified with non-critical materials. It should be non-pressurized and provide a gas tight entrance and exit. Air supply sanitation must depend on chemical treatment or some manually or battery operated ventilation system, and the shelter must function as an emergency expedient rather than a permanent one. It is desirable to provide safe personnel shelter for a minimum of 72 hours.

### Sealing of Shelter

The shelter, being unpressurized, must be air tight or its purpose is defeated. Protection against gas demands the complete sealing of the shelter for personnel protection, since microscopic openings will allow gas to enter.

Methods of sealing the shelter vary widely in cost. The cost should not be excessive and non-critical material should be used. Possible methods of sealing are: (1) a heavy coat of "cocoon" material applied to all walls, (2) covering the walls with a thin sheet of plastic,

metal foil material, asphalt paper, or other vapor barrier material and taping all seams, and (3) using tape, caulking compound or "cocoon" to seal all cracks, windows, and doors.

The cheapest method would be the use of tape and caulking compound. Unfortunately, many standard construction materials are permeable to gas, and a basically impermeable structure is desirable for use of this method.

#### Entrance and Exit

The entrance and exit to an unpressurized shelter must be simple in construction, gas tight and provide protection to personnel within the shelter.

A water-seal, gas-trap entrance as proposed in the project assignment could be used. A fabric tank, installed through a wall or doorway of the chamber would be required. The tank would be filled with water treated with hypochlorite. A 50 ppm solution of chlorinated, pH controlled water would not be harmful to personnel and with scrubbing on the part of personnel using the entrance, might prove effective. The tank could not be set up quickly in case of an emergency and would therefore require previous preparation.

A gas-tight air lock made from a clear, collapsible, plastic crawl-through tube of sufficient diameter for personnel has been proposed. This tube would be of sufficient length to permit a man to crawl through and unseal and seal each end as he passes through the device. Such problems as entrance and exit gas-tight sealing mechanisms, prevention of contamination carry-through and portability, would have to be solved. It is felt that this device could be developed as an emergency means of leaving a shelter. Some contamination would enter the air lock and the shelter when the tube was used repeatedly unless a supply of purified air were available for scavenging.

The many difficulties involved in providing a satisfactory entrance and exit system without some sort of air locks and scavenging air supply makes it seem necessary that a manually operated collective protector is essential for the successful operation of an unpressurized shelter. No other successful method of entrance and exit has yet been demonstrated.

#### Chemical Oxygen Supply

Sodium chlorate candles can furnish oxygen to the unventilated shelter by the thermal decomposition of the chlorate. Figures 1 and 2 show such a chlorate candle. The active life of the chlorate candle is approximately one hour, releasing 70 cubic feet of oxygen and 1000 Btu of heat. The entire canister may reach a temperature of 500F, evolving hot oxygen, and must be handled accordingly. The oxygen outlet is on top of the canister and is sealed with a 1/4" pipe plug (this plug must be removed before pulling the starter ring). The canister must be placed on a non-combustible surface when being used.

### Carbon Dioxide Absorption

The chemicals available have not been tested, but there should be no difficulty with this problem if an absorbent is determined to be desirable.

### Humidity and Temperature Control

Difficulties of humidity and temperature control would be dependent on the wall materials of the enclosure and exterior conditions. Hygroscopic materials aid considerably in minimizing the rise in RH from body or other moisture sources but, unfortunately, hygroscopic building material insulating effects will govern inside temperatures to a large extent. However, since none of the factors can be assumed to be favorable at all times, it is necessary to provide some method of keeping these within safe limits. A sealed room on a hot day would be just as lethal as radiation or BW agents if the combined effect of high temperature and high humidity were not controlled. Potential methods of controlling the humidity are by using an adsorber such as a refrigerated condensing coil or ventilation. Temperature control without using electrical power is difficult, but a manually operated ventilation system seems practical.

For long term shelter occupancy, the upper limit of safe temperature varies with the relative humidity, but in general, the following conditions cause considerable heat stress: 80F at 96 RH, 90F at 90 RH, 95F at 85 RH, and 105F at 60 RH.

### TEST RESULTS

An exploratory test was made to observe the conditions and reactions of personnel confined to a sealed, unpressurized shelter. Five persons were confined to a shelter for four hours. The first three hours were without benefit of added oxygen. A chlorate candle was used for the last hour.

The room selected for this test was 8' x 12' x 9 1/2', with a volume of 910 cu ft. This volume allowed approximately 185 cu ft per person. The shelter was paneled with sheet plywood and the walls were well insulated with fiber glass. All seams, cracks, windows and doors were sealed with tape or caulking compound. For ordinary purposes, the room was air tight.

A recording potentiometer was used to record temperatures during the test. A sling psychrometer and recording psychrometer were used to supplement the thermocouple readings. Pulse rates of all personnel were recorded as an indication of personnel reaction.

The wet and dry bulb temperatures and relative humidity, Figure 3, show a steady increase. The ignition of a chlorate candle at the three hour mark caused a decided increase in the temperature. The relative humidity stabilized at approximately 50%.

The correlation of pulse rate vs. time is shown in Figure 4. There was little discomfort during the first three hours, although some difficulty was noted near the end of that phase of the test. At the end of the third hour of confinement, the pulse rate shows a decided drop after the chlorate candle was ignited. Three curves are used to indicate the decided difference in the reactions among personnel confined to the room. Some were affected very slightly while others were affected quite severely. A need for ventilation or a method of odor absorption can be seen by the irritation caused by six cigarettes smoked and the oppressive feeling from the stuffy air and body odors. It is interesting to note that the odor level in the room became unpleasant to the occupants at the end of four hours, but not unbearable. After these people left the room and breathed fresh air for a few minutes, then went back into the shelter room, the air was almost nauseating. This would be a problem for personnel entering an already occupied shelter.

#### DIFFUSION BARRIER MATERIALS

Reports on this material received so far indicate that it allows limited amounts of moisture vapor and heat to escape from the shelter. Properly applied, it may offer many possibilities, but apparently it is not a "cure-all".

#### DISCUSSION

The most difficult problems encountered in unpressurized shelter construction are the entrance facilities, the temperature and humidity control. To provide an adequate unpressurized shelter, it seems essential that the selection and much of the preparation of the shelter must be made well in advance of any emergency. Such preparations must include construction of the entrance facilities to be used, sealing of the shelter walls, and preparation of a kit to be placed in the enclosure. This kit will include the necessary equipment for final sealing of the shelter at the time of the emergency and the other operational necessities.

The results of the brief test made by Laboratory personnel indicate that 3 to 4 hours is the maximum time that the initial volume of air used in the test will be adequate for respiration under favorable conditions. This is based on having dry, cool air to start with. Longer occupancy requires a method of air purification or supply. There seems to be no reason why a manually operated collective protector of about 25 cfm capacity cannot be devised. In a 10 man, 1500 cubic foot shelter, this 25 cfm can provide one change of air per hour. Probably, one hour's operation out of every two hours would be adequate. A simple exit air lock system would be practical if this type of protection were available.

#### CONCLUSIONS

Investigation of the requirements and equipment available for unpressurized shelters indicate the following:



1. Chemical control of air conditions can be accomplished but the chemicals are expensive and create other problems in temperature control.

2. Entrance to or exit from an unventilated shelter would require a complicated system of air locks or seals.

3. Sealing of existing construction for CBR agents is costly and will usually make the space unsuitable for other uses.

It is therefore concluded that a manually operated collective protector is the most economical method of solving the problems of oxygen, CO<sub>2</sub>, temperature, humidity, and entrance and exit. The necessity for sealing will not be removed, but the quality of sealing required may be reduced. Spaces designated as protective shelters under these conditions may be used for other purposes.

#### PROPOSED FUTURE PLANS

1. Develop a manually operated collective protector for small protective shelters.

2. Develop an inexpensive air lock for entrance and exit with a manually operated decontamination shower.

3. Conduct evaluation tests of these devices in a shelter which is fitted out and sealed in an existing building.

4. With these devices as the key, develop a kit for preparing small protective shelters within existing structures.

5. Prepare a report which discusses the methods, planning, equipment and preparation required for the use of these and other new devices in passive defense organizations.

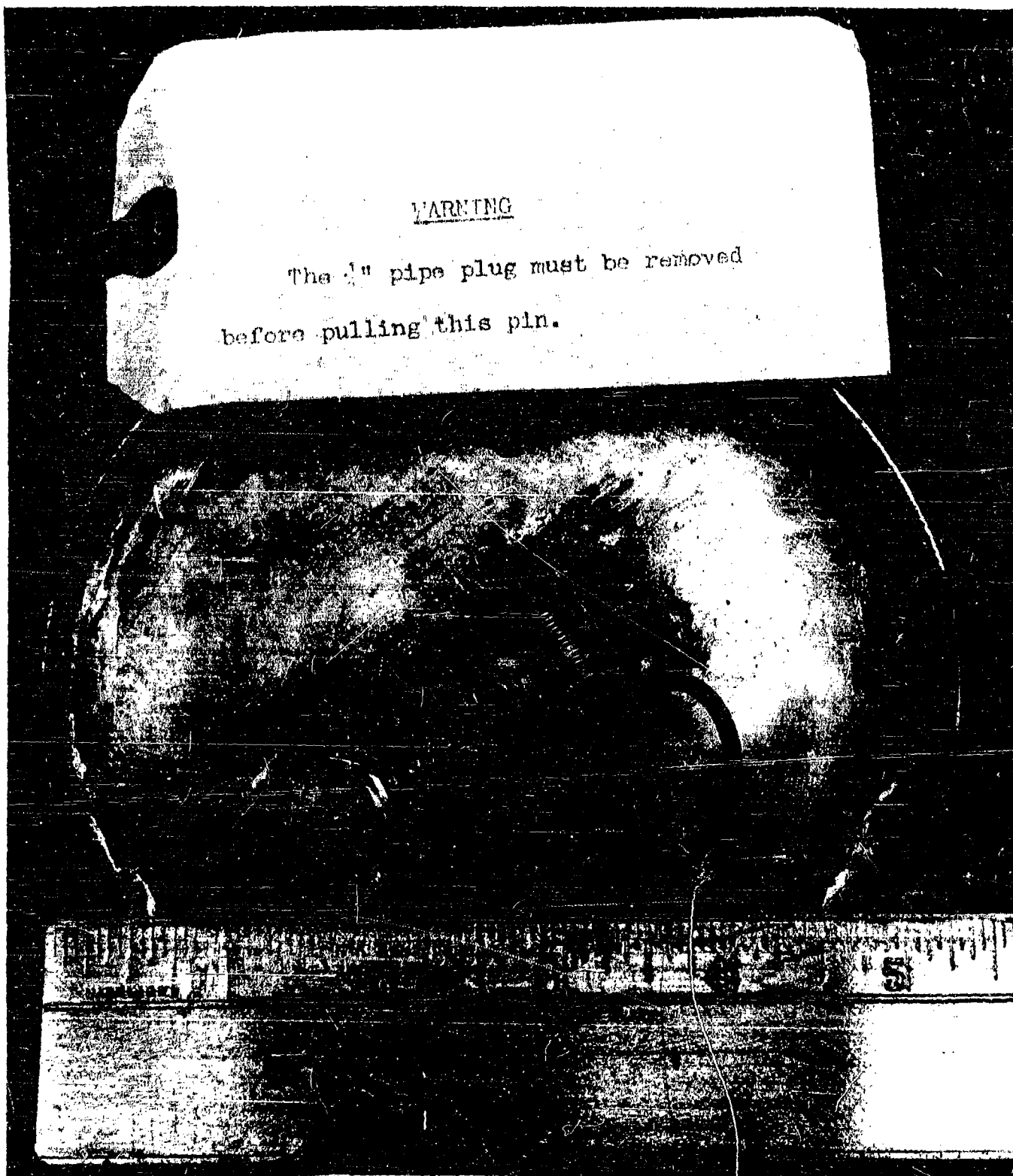


Figure 1. View of top of chlorate candle showing 1/4" plug and firing mechanism. The candle is of brass construction with all seams and permanent fittings brazed to candle body. The warning tag accompanies all candles.



Figure 2. View showing chlorate candle in upright operating position. Cap on top of the chlorate candle protects firing mechanism.

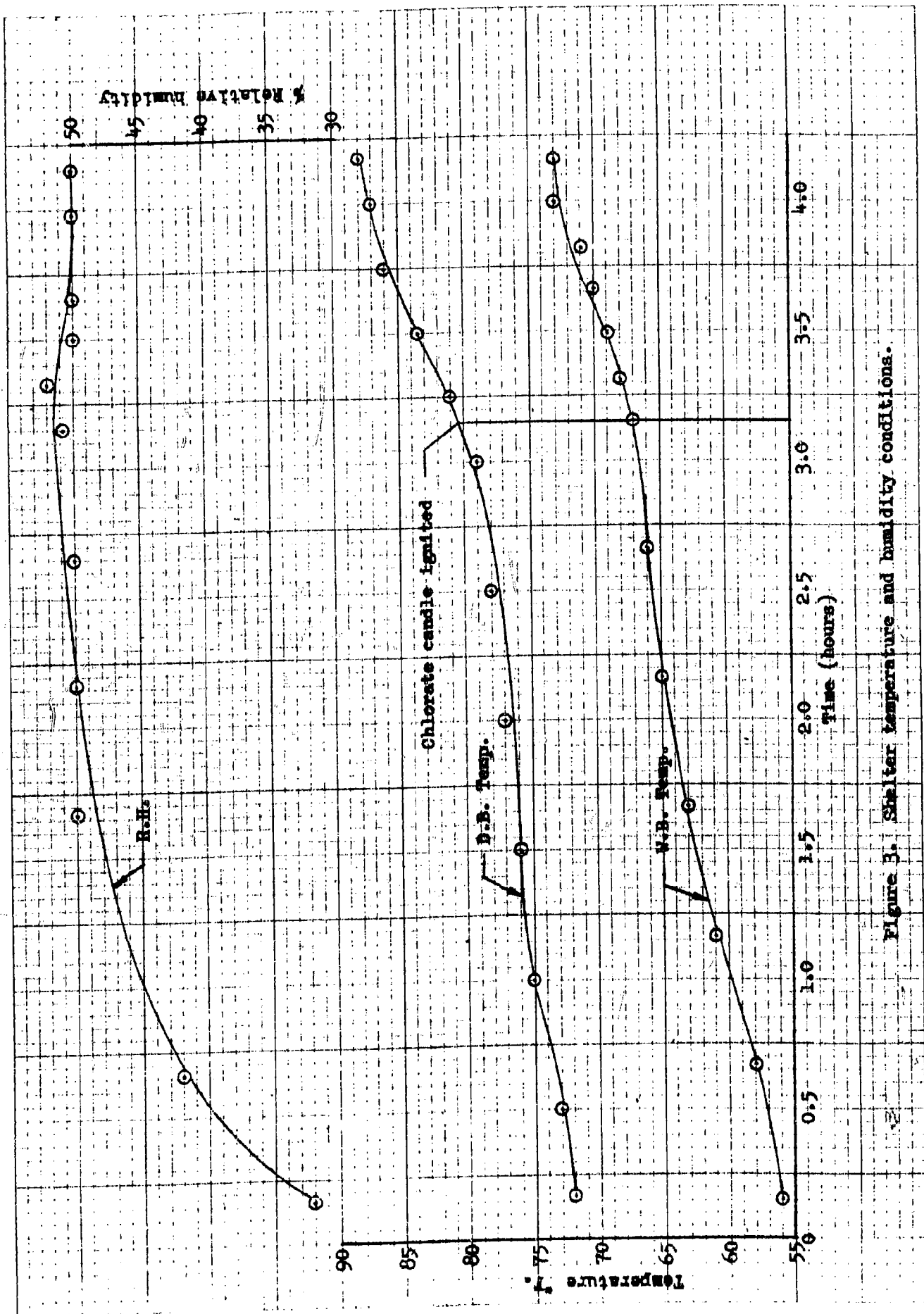


Figure 3. Shelter temperature and humidity conditions.

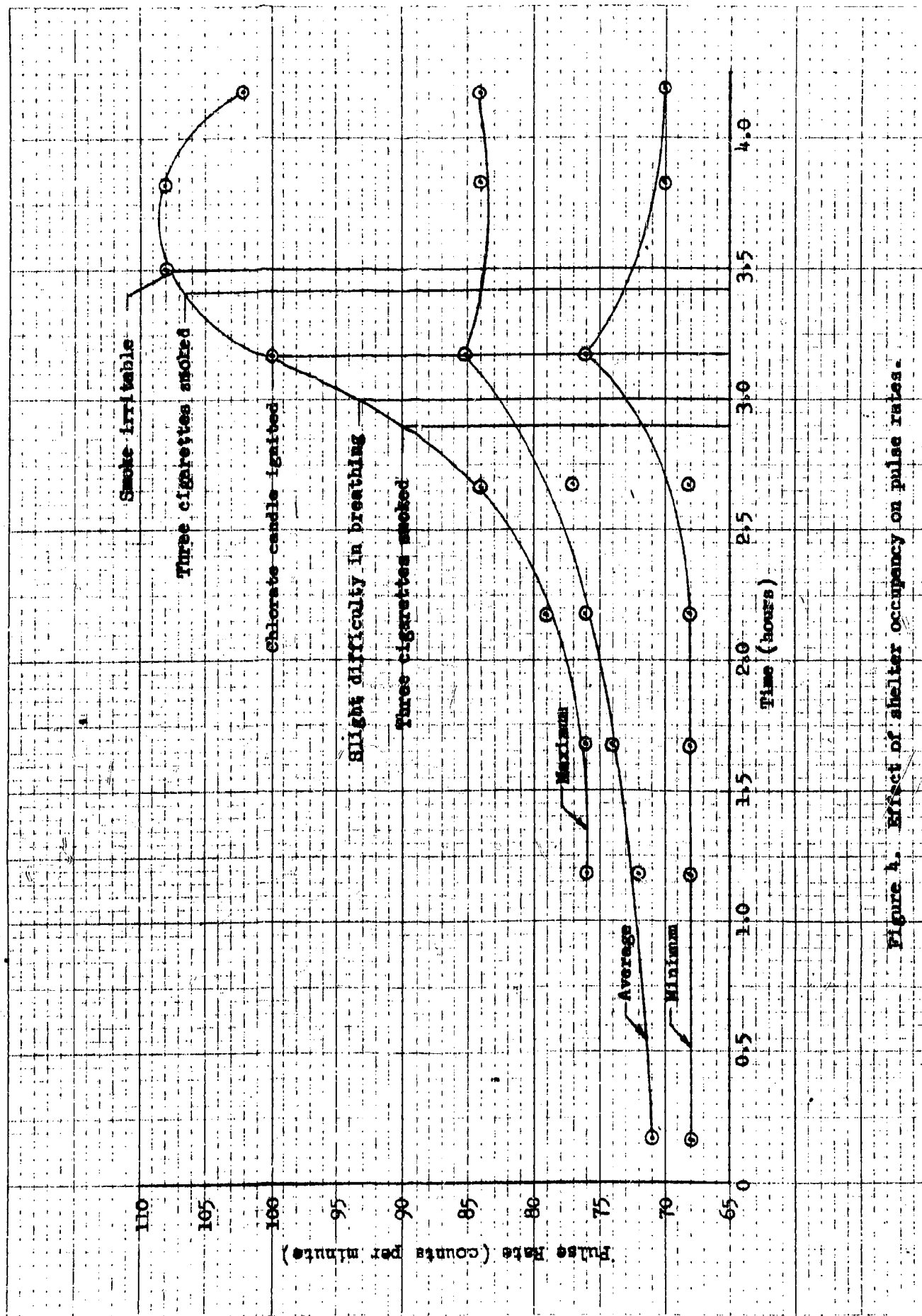


Figure 1. Effect of shelter occupancy on pulse rates.

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